Emergency and Disaster Response to Chemical Releases

Technician Level Training

29 CFR 1910.120(q)

Module 5

Personal Protective Equipment

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Acronyms Used in This Module

APR	Air-Purifying Respirator
CBRN	Chemical, Biological, Radiological, Nuclear
CFR	Code of Federal Regulations
CPC	Chemical Protective Clothing
EPA	Environmental Protection Agency
ID	Identification
IDLH	Immediately Dangerous to Life and Health
MSA	Mine Safety Appliances
MUC	Maximum Use Concentration
MUL	Maximum Use Limit
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PLHCP	Physician or Licensed Healthcare Professional
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
REL	Recommended Exposure Limit
SAR	Supplied Air Respirator
SBR	Styrene Butadiene rubber
SCBA	Self-Contained Breathing Apparatus

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Overview

The proper selection and use of personal protective equipment will ensure that when an individual responds to an emergency situation the threat of contamination and injury is greatly reduced. The understanding that no single combination of protective equipment and clothing is capable of protecting against all hazards is equally important.

Terminal Learning Objective

Upon completion of this module, the participant will be able to describe the proper procedures to use when selecting and using personal protective equipment during disaster and emergency response to chemical releases.

Enabling Objectives

At the conclusion of this module, the participant will be able to:

- Describe PPE over-protection and under-protection.
- Rank the level of protection provided by different respirators.
- List two factors that affect the protection provided by an air-purifying respirator.
- Describe procedures for the selection and inspection of chemical protective clothing.
- List measures that can be taken to minimize the risk of heat-related injuries.

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Introduction

Anyone responding to a hazardous materials spill must be protected against potential hazards. The purpose of chemical protective clothing (CPC) and personal protective equipment (PPE) is to shield or isolate individuals from the chemical, physical, and biological hazards that may be encountered. Careful selection and use of adequate PPE should protect the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing.

Use of PPE is required by Occupational Safety and Health Administration (OSHA) regulations in 29 CFR Part 1910.120 & 1910.134 and reinforced by U.S. Environmental Protection Agency (EPA) regulations in 40 CFR Part 300.

No single combination of protective equipment and clothing is capable of protecting against all hazards. Thus, PPE should be used in conjunction with other protective methods. The use of PPE can itself create significant responder hazards, such as heat stress, physical and psychological stress, impaired vision, mobility, and communication. In general, the greater the level of PPE protection, the greater is the associated risks. For any given situation, equipment and clothing should be selected that provide an adequate level of protection. Over-protection as well as under-protection can be hazardous and should be avoided.

Respiratory Protection

Respiratory protection is of primary importance since inhalation is one of the major routes of exposure to chemical toxins. Respiratory protective devices (respirators) consist of a facepiece connected to either an air source or an air-purifying device.

Supplied Air

Respirators with an air source are called atmosphere-supplying respirators and consist of two types:

- Supplied-air respirators (SARs) supply air from a source located some distance away and connect to the user by an airline hose. Supplied-air respirators are sometimes referred to as airline respirators. Only SARs with an emergency escape air supply may be used in IDLH areas.

- Self-contained breathing apparatus (SCBA) supplies air from a source carried by the user.

- Positive-pressure respirators maintain a positive pressure in the facepiece during both inhalation and exhalation. The two main types of positive-pressure respirators are pressure-demand and continuous flow. In pressure-demand respirators, a pressure regulator and an exhalation valve on the mask maintain the mask's positive pressure except during high breathing rates. If a leak develops in a pressure-demand respirator, the regulator sends a continuous flow of clean air into the facepiece, preventing penetration by contaminated ambient air.

SCBA

A self-contained breathing apparatus (SCBA) usually consists of a facepiece connected by a hose and a regulator to an air source (compressed air, compressed oxygen, or an oxygen-generating chemical) carried by the wearer. Only positive-pressure SCBAs are used for entry into atmospheres that are immediately dangerous to life and health (IDLH). SCBAs offer protection against most types and levels of airborne contaminants. However, the duration of the air supply is an important planning factor in SCBA use. Due to their bulk and weight, SCBA use may increase the likelihood of heat stress and impair movement, particularly in confined spaces.

Employees engaged in emergency response to spills and release and exposed to hazardous substances presenting an inhalation hazard or potential inhalation hazard shall wear positive pressure self-contained breathing apparatus (SCBA).

SCBAs shall continue to be worn until the individual in charge determines, through the use of air monitoring, that a decreased level of respiratory protection will not result in hazardous exposures to employees.

APR

Air-purifying respirators *(APRs)*, on the other hand, do not have a separate air source. Instead, they utilize ambient air that is "purified" through a filtering element prior to inhalation.

Negative-pressure respirators draw air into the facepiece via the negative pressure created by user inhalation. The main disadvantage of

negative-pressure respirators is that if any leaks develop in the system (i.e., a crack in the hose or an ill-fitting mask or facepiece), the user draws contaminated air into the facepiece during inhalation.

Different types of facepieces are available for use with the various types of respirators. The types generally used are half-face and full-face. Full-face masks cover the face from the hairline to below the chin, providing eye protection, where half masks cover the face from below the chin to over the nose and do not provide eye protection.

Half-face

Full-face

Air-purifying respirators consist of a facepiece and an air-purifying device, which is either a removable component of the facepiece or an air-purifying apparatus worn on a body harness and attached to the facepiece by a corrugated breathing hose. Air-purifying respirators selectively remove specific airborne contaminants (particulates, gases, vapors, and fumes) from ambient air by filtration, absorption, adsorption, or chemical reactions. They are approved for use in atmospheres containing specific chemicals up to designated concentrations but not for IDLH atmospheres. Air-purifying respirators can be used only when the ambient atmosphere contains sufficient oxygen (more than 19.5 percent).

Air-purifying respirators usually operate only in the negative-pressure mode. There are three types of air-purifying devices:

- Particulate filters
- Cartridges and canisters, which contain sorbents for specific gases and vapors
- Combination devices

Cartridges usually attach directly to the respirator facepiece. The larger-volume canisters attach to the chin of the facepiece or are carried with a

harness and attached to the facepiece by a breathing tube. Cartridges have maximum use concentrations (MUC) specified on the cartridge or in the package the cartridge is sealed in. *The maximum use limit (MUL) must also be considered.*

Medical Surveillance

Every responder who will be required to wear respiratory protection shall have a physical examination to determine his or her fitness to wear a respirator. The examining physician or licensed healthcare professional (PLHCP) determines whether or not the individual will be restricted from wearing respiratory protective equipment. Specific medical tests and procedures will be in accordance with OSHA and the employer's physician requirements.

Response personnel may need to have additional medical evaluation beyond the annual examination required by 29 CFR 1910.120 as specified in 29 CFR 1910.1349e)(7) by a PLHCP to review the employees continued fitness to wear a respirator. At the discretion of the PLHCP, a more frequent schedule of physical exams may be needed.

Respirator Fit Testing

A fit test shall be used to determine the ability of each individual respirator wearer to obtain a satisfactory fit with any respirator. A quantitative fit test will be performed. Personnel must successfully pass the fit test before being issued a respirator. No responder is permitted to wear a respirator in a work situation until he or she has demonstrated that an acceptable fit can be obtained. Respirator fitting is conducted initially upon assignment to a task requiring use of a respirator. Refitting will be conducted annually.

Protection Factor

The level of protection that can be provided by a respirator is indicated by the respirator's protection factor. This number, which is determined experimentally by measuring facepiece seal and exhalation valve leakage, indicates the relative difference in concentrations of substances outside and inside the facepiece that can be maintained by the respirator. As seen in the following chart, the protection factor for full-

facepiece air-purifying respirators is 50. This means, theoretically, that responders wearing these respirators should be protected in atmospheres containing chemicals at concentrations that are up to 50 times higher than the PEL for that contaminant.

APF	Respirator
10	Half-facepiece respirator with vapor cartridge* or filter
50	Full-facepiece respirator with vapor cartridge* or filter
1,000	Full-facepiece supplied air respirator operated in pressure-demand mode.
1,000 to 10,0000	Full-facepiece self-contained breathing apparatus operated in pressure demand mode
*Cartridges have maximum use concentrations specified on the cartridge or package. Use the lesser of the cartridge / filter concentration or protection factor.	

It should be remembered that the protection provided by a respirator could be compromised in several situations, most notably:

- If a responder has a high breathing rate.
- If the ambient temperature is high or low.
- If the responder has a poor facepiece-to-face seal.

At high breathing rates positive-pressure SCBAs and SARs may not maintain positive pressure for brief periods during peak inhalation. Also, at high work rates, exhalation valves may leak. Consequently, positive-pressure respirators working at high flow rates may offer less protection than when working at normal rates.

A similar reduction in protection may result from high or low ambient temperatures. For example, at high temperatures, excessive sweat may cause a break in the face-to-facepiece seal. Likewise, a poor facepiece seal, due to such factors as facial hair, missing teeth, scars, lack of or improper fit testing, etc., can result in the penetration of air contaminants.

Organic and acid gas cartridges (yellow) are not to be used in atmospheres containing more then 1,000 ppm organic vapors, 10 ppm chlorine gas, 50 ppm hydrochloric acid vapors or gas, 50 ppm sulfur dioxide gas, or 10 ppm formaldehyde gas. Combination canisters and cartridges contain layers of different sorbant materials and remove multiple chemicals or multiple classes of chemicals from the ambient air. They are color-coded to indicate the general chemicals or classes of chemicals against which they are effective. Some examples can be seen on the following chart.

Respirator Cartridge/Filters	
Color	Approved For
Black	Organic vapors
Yellow	Organic vapors and acid gases
White	Acid gases
Green	Ammonia and methylamine
Magenta	HEPA, dusts, fumes, and mists
Orange stripe	Used for dusts, fumes, and mists in combination with any vapor or gas

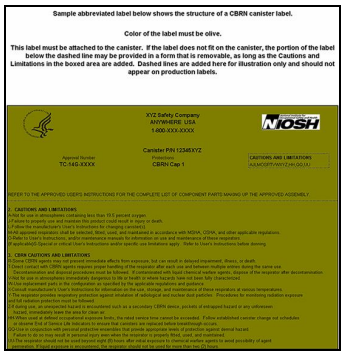
CBRN Respirators

APR

To determine if a given APR has been tested and certified by NIOSH for use by emergency responders in CBRN environments, you must check for one of three Cap labels. The three types of labels that are included with a CBRN APR respirator are:

- A full canister label located on the canister.
- A matrix-style canister approval label.
- A matrix-style respirator approval label.

The matrix-style approval labels are part of the users instructions or included as an insert with the packaging. All three labels include TC number and CBRN protection level in addition to other respirator/canister information.


Sample abbreviated label below shows the structure of a CBRN canister label.

Color of the label must be olive.

This label must be attached to the canister. If the label does not fit on the canister, the portion of the label below the dashed line may be provided in a form that is removable, as long as the Cautions and Limitations in the boxed area are added. Dashed lines are added here for illustration only and should not appear on production labels.

XYZ Safety Company
ANYWHERE USA
1-800-XXX-XXXX

Canister P/N 12345XYZ

Approval Number
TC-14G-XXXX

Protection
CBRN Cap 1

CAUTIONS AND LIMITATIONS

REFER TO THE APPROVED USER'S INSTRUCTIONS FOR THE COMPLETE LIST OF COMPONENT PARTS MAKING UP THE APPROVED ASSEMBLY.

Look to see if the full canister label is like the one shown in Figure 1. Canister labels will specify the CBRN protection level (CBRN Cap 1, CBRN Cap 2, or CBRN Cap 3).

When a canister or cartridge is being used to protect against gases or vapors, the appropriate device shall be used only if the chemical(s) have "adequate warning properties." Adequate warning properties are when odor, taste, or irritant effects are detectable and persistent at concentrations below the recommended exposure limit (REL). A substance is considered to have poor warning properties when its odor or irritation threshold is above the applicable exposure limit.

Warning properties are essential for safe use of air-purifying respirators as these properties allow for detection of a contaminant should break through occur.

SCBA

The National Institute for Occupational Safety and Health (NIOSH) is testing and certifying self-contained breathing apparatus (SCBA) for use by emergency responders in chemical, biological, radiological, and nuclear (CBRN) environments. Only a limited number of models have been certified to date. The devices certified to date are certain versions of some models manufactured by Mine Safety Appliances Company (MSA); Interspiro, USA; Scott Health and Safety; Draeger Safety Inc.; International Safety Instruments, Inc.; and Survivair.

To determine if a given SCBA has been tested and certified by NIOSH for use by emergency responders for use in CBRN environments, look to see if the CBRN Agent Approval label shown below is on the respirator.

If an SCBA is CBRN-approved by NIOSH, it will always carry this label. If this CBRN Agent Approval label is not on the SCBA, the device is not approved by NIOSH for use by emergency responders in CBRN environments. Check the Label!

Selection of Protective Clothing and Accessories

Chemical-protective clothing (CPC) is available in a variety of materials that offer a range of protection against different chemicals. The most appropriate clothing material will depend on the chemicals present and the task to be accomplished. Ideally the chosen material resists permeation, degradation, and penetration.

Permeation is the process by which a chemical dissolves in and/or moves through a protective clothing material on a molecular level.

Degradation is the loss of or change in the fabric's chemical resistance or physical properties due to exposure to chemicals, use, or ambient conditions (e.g., sunlight).

Penetration is the movement of chemicals through zippers, stitched seams or imperfections (e.g., pinholes) in protective clothing material.

Other Considerations

In addition to permeation, degradation, and penetration, several other factors must be considered during clothing selection. These affect not only chemical resistance but also the responder's ability to perform the required task. The following checklist summarizes these considerations.

Durability

Does the material have sufficient strength to withstand the physical stress of the task(s) at hand?

Will the material resist tears, punctures, and abrasions?

Will the material withstand repeated use after contamination or decontamination?

Flexibility

Will the CPC interfere with the responders' ability to perform their assigned tasks?

This is particularly important when considering gloves.

Effects of Temperature

Will the material maintain its protective integrity and flexibility under hot and cold extremes?

Ease of Decontamination

Are decontamination procedures available on site?

Will the material pose any decontamination problems?

Should disposable clothing be used?

Compatibility With Other Equipment

Does the clothing preclude the use of another, necessary piece of protective equipment (e.g., suits that preclude hard-hat use in hard-hat area)?

Duration of Use

Can the required task be accomplished before contaminant breakthrough occurs or degradation of the CPC becomes significant?

Special Conditions

Fire, explosion, heat, and radiation are considered special conditions that require special-protective equipment.

Levels of Protection

The individual components of clothing and equipment must be assembled into a full protective ensemble that both protects the responder from the site-specific hazards and minimizes the hazards and drawbacks of the PPE ensemble itself.

EPA levels of protection are Levels A, B, C, and D. In addition, standard fire protective clothing ensemble is listed. The type of equipment used and the overall level of protection should be re-evaluated periodically as the amount of information about the hazardous materials and the release increases.

CHEMICAL PROTECTIVE CLOTHING

	LEVEL A	LEVEL B
PROTECTION PROVIDED:	The highest level of respiratory, skin, and eye protection available.	The highest level of respiratory protection but limited skin protection from airborne hazards (gases, vapors, dusts, and mists).
RECOMMENDED:	Pressure-demand full-facepiece SCBA or pressure-demand, supplied-air respirator with escape SCBA. Fully encapsulating, chemical-resistant suit. Disposable coveralls to be used over work clothes and under chemical-resistant clothing. Inner and outer chemical-resistant gloves. Chemical-resistant boots. Hard hat. 	Pressure-demand full-facepiece SCBA or pressure-demand supplied-air respirator with escape SCBA. Chemical-resistant clothing: overalls and long-sleeved jacket; hooded, one or two piece chemical splash suit; limited use chemical-resistant one piece suit. Disposable coveralls to be used over work clothes and under chemical-resistant clothing. Inner and outer chemical-resistant gloves. Chemical-resistant boots. Hard hat. 
OPTIONAL:	Disposable boot covers. Taped seams. Cooling unit.	Disposable boot covers. Taped seams.
LIMITING CRITERIA:	Fully encapsulating suit material must be compatible with chemicals involved. Site conditions, such as temperature, may require close observation of responders' comfort. This is the level recommended for site entries if operations involve high potential for splash or for exposure to vapors, gases, or particles that have high degree of hazard to the skin.	Use only when the vapor or gases are NOT suspected of containing high concentrations of chemicals that are harmful to skin or capable of being absorbed through intact skin. Use only when it is highly unlikely that the work being done will generate either high concentrations of vapors, gases, particles, or splashes of material that will affect exposed skin. This is the minimum level recommended for initial site entries until the hazards have been further identified.

CHEMICAL PROTECTIVE CLOTHING

	LEVEL C	LEVEL D
PROTECTION PROVIDED:	A limited level of respiratory protection and skin protection from airborne (gases, vapors, dusts, mists) hazards.	No respiratory protection and limited skin protection from airborne (gases, vapors, dusts, mists) hazards.
RECOMMENDED:	Full-face, air-purifying respirator. Chemical-resistant clothing: overalls and long-sleeved jacket; (hooded), one or two piece chemical splash suit; limited-use chemical-resistant one-piece suit. Disposable coveralls to be used over work clothes and under chemical-resistant clothing. Inner and outer chemical-resistant gloves. Chemical-resistant boots. Hard hat. 	Disposable coveralls to be used over work clothes. Work gloves. Chemical-resistant boots or shoes. Safety glasses or goggles. Hard hat. 
OPTIONAL:	Disposable boot covers. Taped seams. Escape mask.	Escape mask.
LIMITING CRITERIA:	Atmospheric concentrations of chemicals must not exceed IDLH levels. Protection factor of respirator must not be exceeded, chemicals must have adequate warning properties and the atmosphere must contain at least 19.5% oxygen. This level can be used only when all atmospheric contaminants have been identified, concentrations measured, and it has been determined that the air-purifying respirator can remove the contaminants.	Atmospheric concentrations of chemicals must not exceed TLV levels and the atmosphere must contain at least 19.5% oxygen. This level can be used only when all atmospheric contaminants have been identified, concentrations measured, and it has been determined that there is no hazard to the respiratory system or to the skin.

CHEMICAL PROTECTIVE CLOTHING

	FIRE PROTECTIVE CLOTHING
PROTECTION PROVIDED:	Respiratory protection and skin protection from heat, steam, hot particles, and airborne (gases, vapors, dusts, mists) hazards generated by combustion.
RECOMMENDED:	Coat and pants of fire-resistive materials with an outer shell vapor barrier and thermal liner. Pressure-demand full facepiece SCBA. Heat-resistant hood for head and neck protection. Helmet with chinstrap and earflaps. Boots, steel toes, steel shank, slip resistant, water resistant. Gloves, leather fire fighters.
OPTIONAL:	Rubber overgloves. Fire-resistant coveralls.
LIMITING CRITERIA:	Firefighters protective clothing is not designed for chemical exposure from splash or other physical contact. It is designed to protect wearer from heat, not direct flame contact. This is the minimum level recommended for initial site entries when flammable liquids or gases may have been released.

Types of Ensembles

There are numerous types of ensembles that can be tailored to a specific situation. Each level of protection can be subdivided into several groups. In general, the groups are arranged in decreasing levels of protection based on the primary piece of clothing. Examples are provided for Level B and Level C below.

Level B ensembles that offer maximum respiratory protection and varying levels of liquid splash protection are divided between:

- Fire-resistant NFPA-approved total body coveralls made of multiple layers of chemical and fire-resistant fabric complete

with hood, cape and built-in face shield. Cape covers shoulders, chest, SCBA, and back.

- Limited-use encapsulated suits made of multiple layers of chemical-resistant films bonded to fabric. Suits are light and offer a broad chemical resistance. Common brands include Barricade™, Responder™, Chemrel Max™, and Saranex™. The encapsulation provides total splash protection and excellent protection for SCBAs.
- Limited-use total body coveralls made of multiple layers of chemical-resistant films bonded to fabric. Suits are light and offer a broad chemical resistance. Common brands include Barricade™, Responder ™, Chemrel™, Chemrel Max™, and Saranex™.
- Rain and acid splash coveralls made of materials like PVC-coated nylon, polyurethane-coated nylon, neoprene-coated nylon, SBR rubber-over-neoprene, or butyl-coated nylon.
- Rain and acid splash two-piece suits made of materials like PVC-coated nylon, polyurethane-coated nylon, neoprene-coated nylon, SBR rubber-over-neoprene or butyl-coated nylon.
- Lightweight Tyvek™ suits, coated with polyethylene film or Saranex™ film.
- Lightweight splash suits made of vinyl or poly-vinylchloride (PVC). One-piece coveralls or two-piece suits.

Level C ensembles that offer respiratory protection for known concentrations of selected chemicals and varying levels of liquid splash protection are divided between:

- Limited-use total body coveralls made of multiple layers of chemical resistant films bonded to fabric. Suits are light and offer a broad chemical resistance. Common brands include Barricade™, Responder™, Chemrel™, Chemrel Max™, and Saranex™.

- Rain and acid splash coveralls made of materials like PVC-coated nylon, polyurethane-coated nylon, neoprene-coated nylon, SBR-rubber-over-neoprene, or butyl-coated nylon.
- Rain and acid splash two-piece suits made of materials like PVC-coated nylon; polyurethane-coated nylon, neoprene-coated-nylon; Styrene Butadiene (SBR) rubber-over-neoprene or butyl-coated nylon.
- Lightweight Tyvek™ suits coated with polyethylene film or Saranex™ film.

- Lightweight Tyvek™, perforated Tyvek™, or Kleenguard ™ suits.

The type of equipment used and the overall level of protection should be re-evaluated periodically as the amount of information about the hazardous materials and the release increases.

PPE Inspection Program

An effective PPE inspection program will probably feature five different types of inspection:

1. Inspection and operational testing of equipment received from the factory or distributor.

2. Inspection of equipment as it is issued to responders.

3. Inspection after use or training and prior to maintenance.

4. Periodic inspection of stored equipment.

5. Periodic inspection when a question arises concerning the appropriateness of the selected equipment, or when problems with similar equipment arise.

Each inspection will cover somewhat different areas in varying degrees of depth. Detailed inspection procedures, where appropriate, are usually available from the manufacturer.

Records must be kept of all inspection procedures. Individual identification numbers should be assigned to all reusable pieces of equipment (respirators may already have ID numbers). During inspection record the ID number, date, inspector, and any unusual conditions or findings. Periodic review of these records may indicate an item or type of item with excessive maintenance costs or a particularly high level of "downtime."

Storage

Clothing and respirators must be stored properly to prevent damage or malfunction from exposure to dust, moisture, sunlight, damaging chemicals, extreme temperatures, and impact. Procedures must be specified for both pre-issuance warehousing and, more importantly, post-issuance (in-use) storage. Many equipment failures can be directly attributed to improper storage.

Clothing

Potentially contaminated clothing should be stored in an area separate from street clothing. Potentially contaminated clothing should be stored in a well-ventilated area, with good airflow around each item, if possible.

CHEMICAL PROTECTIVE CLOTHING

Inspection Checklist Before Use for
ALL SUITS and CLOTHING

- Determine that the clothing material is correct for the specified task at hand.
- Visually inspect for:
  - imperfect seams
  - non-uniform coatings
  - tears
  - malfunctioning closures
- Hold up to light and check for pinholes.
- Flex product:
  - observe for cracks
  - observe for signs of self-deterioration
- If the product has been used previously, inspect inside and out for signs of chemical attack:
  - discoloration
  - swelling
  - stiffness

Gloves

Pressurize glove to check for pinholes. Either blow into glove, then roll gauntlet towards fingers or inflate glove and hold under water. In either case, no air should escape.

Chemical Protective Clothing

Level A Donning Procedure

1. Inspect the clothing and respiratory equipment before donning.
2. If hard hat or headpiece is to be worn, adjust to fit user's head.
3. Standing or sitting, step into the legs of the suit; ensure proper placement of feet within the suit; then gather the suit around the waist.
4. Put on chemical-resistant safety boots over the feet of the suit; tape the leg cuff over the tops of the boots.
5. If overboots are to be used, put these on next and complete boot taping.
6. Put on air tanks and harness assembly of the SCBA. Don the facepiece and adjust it to be secure, but comfortable. Do not connect the breathing hose. Open the valve on the air tank.
7. Perform negative and positive respirator facepiece seal test procedures.
8. Put on inner gloves (surgical gloves).
9. Put on basic gloves if not attached to suit.
10. Put sleeves of suit over arms as assistant pulls suit up and over the SCBA. Assistant adjusts suit around SCBA and shoulders to ensure unrestricted motion.
11. Put on hard hat if needed.
12. Put on outer gloves and tape as needed.
13. Raise hood over head carefully so as not to disrupt face seal of SCBA mask. Adjust hood to give satisfactory comfort.
14. Begin to secure the suit by closing all fasteners on opening until there is only adequate room to connect the breathing hose. Secure all belts and/or adjustable leg, head, and waistbands.
15. Connect the breathing hose while opening the main valve.
16. Have assistant check that wearer is breathing properly and then make final closure of the suit.
17. Have assistant check all closures.
18. Have assistant observe the wearer for a period of time to ensure that the wearer is comfortable, psychologically stable, and that all equipment is functioning properly.

Chemical Protective Clothing

Donning Procedure for Level B

1. Inspect the clothing and respiratory equipment before donning.
2. Adjust hard hat or headpiece, if to be worn, to fit user's head.
3. Standing or sitting, step into the legs of the suit; ensure proper placement of feet within the suit; then gather the suit around the waist.
4. Put on chemical-resistant safety boots; tape the leg cuff over the tops of the boots at the top of the boot.
5. If overboots are to be used, put these on now and complete taping of the boots.
6. Don the facepiece and adjust it to be secure, but comfortable. Do not connect the breathing hose.
7. Perform negative and positive respirator facepiece seal test procedures.
8. Put on inner gloves (surgical gloves).
9. Put on basic or outer glove.
10. Put sleeves of suit over arms and shoulders. Have assistant adjust suit to ensure unrestricted motion. Secure the suit by closing all fasteners. Secure all belts and or adjustable leg, head, and waistbands. Tape gloves to suit.
11. Put on air tanks and the harness assembly of the SCBA. Open the valve on the air tank.
12. Raise hood over head carefully so as not to disrupt face seal of SCBA mask. Adjust hood to give satisfactory comfort. Tape hood to facepiece if needed.
13. Put on outer glove (third) if used; tape, if needed.
14. Put on hard hat.
15. Connect the breathing hose while opening the main valve.
16. Have assistant check that the wearer is breathing properly and is comfortable, psychologically and physically stable, and that all equipment is functioning properly.

Clothing Reuse

Chemicals that have begun to permeate clothing during use may not be removed during decontamination and may continue to diffuse through the material towards the inside surface, presenting the hazard of direct skin contact to the next person who uses the clothing. Where such potential hazards may develop, clothing should be checked inside and out for discoloration or other evidence of contamination. Note, however, that negative (i.e., no chemical found) test results do not necessarily preclude the possibility that some absorbed chemical will reach the suit's interior.

Heat Stress and Other Physiological Factors

Wearing PPE puts a spill response responder at considerable risk of developing heat stress. This can result in health effects ranging from transient heat fatigue to serious illness or death. Heat stress can be caused by a number of interacting factors, including environmental conditions, clothing, workload, and the individual characteristics of the responder. Because heat stress is probably one of the most common (and potentially serious) illnesses at spill incidents, regular monitoring and other preventive precautions are vital.

Individuals vary in their susceptibility to heat stress. Factors that may predispose someone to heat stress include:

- Lack of physical fitness.
- Lack of acclimatization.
- Age.
- Dehydration.
- Obesity.
- Alcohol and drug use.
- Infection.
- Sunburn.
- Diarrhea.
- Chronic disease.

The amount and type of PPE worn directly influences reduced work tolerance and the increased risk of excessive heat stress. PPE adds weight and bulk, severely reduces the body's access to normal heat exchange mechanisms (evaporation, convection, and radiation), and increases energy expenditure. Therefore, when selecting PPE, each item's benefit should be carefully evaluated in relation to its potential for increasing the risk of heat stress.

Once PPE is selected, the safe duration of work/rest periods should be determined based on the:

- Anticipated work rate.
- Ambient temperature and other environmental factors.
- Type of protective ensemble.
- Individual responder characteristics and fitness.

Monitoring PPE and Responders

The wearer must understand all aspects of the clothing operation and its limitations. During equipment use, responders should be encouraged to report any perceived problems or difficulties to their supervisor(s). These malfunctions include, but are not limited to:

- Degradation of the protective ensemble.
- Perception of odors.
- Skin irritation.
- Unusual residues on PPE.
- Discomfort.
- Resistance to breathing.
- Fatigue due to respirator use.
- Interference with vision or communication.
- Restriction of movement.
- Personal responses such as rapid pulse, nausea, and chest pain.

Because the incidence of heat stress depends on a variety of factors, all responders, even those not wearing protective equipment, should be monitored. For responders wearing semi-permeable or impermeable encapsulating ensembles, the responders should be monitored when the temperature in the work area is above 70^0 F (21^0 C) or when multiple entries are made in the same shift.

To monitor the responder, measure:

- Heart rate. Count the radial pulse during a 30-second period as early as possible in the rest period.

- If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third and keep the rest period the same.
- If the heart rate still exceeds 110 beats per minute at the next rest period, shorten the following work cycle by one-third.

- Oral temperature. Use a clinical thermometer (three minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).

- If oral temperature exceeds 99.60 F (37.60C), shorten the next work cycle by one-third without changing the rest period.

- If oral temperature still exceeds 99.60 F (37.60C) at the beginning of the next rest period, shorten the following work cycle by one-third.

- Do not permit a responder to wear a semi-permeable or impermeable garment when his/her oral temperature exceeds 100.60F (38.10C).

- Monitor weight and ensure proper hydration.

Initially, the frequency of physiological monitoring depends on the air temperature adjusted for solar radiation and the level of physical work. The length of the work cycle will be governed by the frequency of the required physiological monitoring.

Prevention of Temperature Related Injuries

Proper training and preventive measures will help avert serious illness and loss of response productivity. Preventing heat stress is particularly important because once someone suffers from heat stroke or heat exhaustion, that person may be predisposed to additional heat injuries.

To avoid heat stress, take the following steps:

- Adjust work schedules.
- Modify work/rest schedules according to monitoring requirements.
- Rotate personnel.
- Alternate job functions to minimize overstress or overexertion at one task.
- Add additional personnel to work teams.
- Provide shelter (air-conditioned, if possible) or shaded areas to protect personnel during rest periods.
- Maintain responder's body fluids at normal levels. This is necessary to ensure that the cardiovascular system functions adequately. Daily fluid intake must approximately equal the amount of water lost in sweat; i.e., 8 fluid ounces (0.23 liters) of water must be ingested for approximately every 8 ounces (0.23 kg) of weight lost.

  The normal thirst mechanism is not sensitive enough to ensure that enough water will be ingested to replace lost sweat.

When heavy sweating occurs, encourage the responder to drink more. The following strategies may be useful:

- Maintain water temperature at 500 to 600 F (100 to 15.60 C).
- Provide small disposable cups that hold about 4 ounces (0.1 liter).
- Have responders drink 16 ounces (0.5 liter) of fluid (preferably water or dilute drinks) before beginning work.
- Urge responders to drink a cup or two every 15 to 20 minutes, or at each monitoring break. A total of 1 to 1.6 gallons (4 to 6 liters) of fluid per day are recommended, but more may be necessary to maintain body weight.
- Weigh responders before and after work to determine if fluid replacement is adequate.

Summary

This module introduced the various levels of PPE that responders might use at an incident site and familiarized the responder with this equipment.

Level A dressout and equipment is used in unknown environments where maximum skin and respiratory protection are necessary.

Level B dressout and equipment is used where maximum respiratory protection is required but the response atmosphere does not provide a skin exposure hazard.

Level C provides protection against some radiological particulate hazards and biological agents if the appropriate filters on the air purifying respirator (APR) are used. It is important to know and understand the environment in which one will be working as well as the filter capability on the APR.

In order to use PPE, equipment, one must be trained. Use only PPE that is NIOSH certified, and always use PPE within its stated protection limits. After removing the PPE take immediate steps to reduce heat stress (drinking water, resting, etc.) and perform personal decon (hygiene).

Review Questions

1. Describe how the use of PPE can be hazardous to the responder in a spill response incident.

2. The concentration of a hazardous chemical is 100 times higher than the PEL. What respirator(s) would be acceptable in this situation?

3. What factors can compromise the protection provided by an air-purifying respirator?

4. What type of respirator must employees wear when engaged in emergency response to spills and releases and exposed to hazardous substances with an inhalation or potential inhalation hazard?

5. List four considerations for selecting protective clothing.

6. A hazardous liquid chemical spill has occurred. The liquid presents a skin contact hazard. The vapors present an inhalation hazard but no skin hazard. Airborne concentrations are not known. What protective ensemble should a spill response responder wear?

7. List all pieces of protective ensemble to be utilized.

8. Describe how you would inspect chemical protective clothing prior to donning.

9. Describe three measures that can be taken to prevent heat stress.

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